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Consumption of Fish From Polluted Waters by WIC Participants in East Harlem

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ABSTRACT *To minimize exposure to neurotoxins such as mercury, polychlorinated biphenyls (PCBs), dioxins, and pesticide residues, the New York State Department of Health issues health advisories about consumption of certain fish and shellfish caught from polluted local waters. Fetal exposure causes cognitive developmental deficits in children. Consumption of fish was assessed. We surveyed 220 WIC (Special Supplemental Nutrition Program for Women, Infants, and Children) participants. Of the participants, 10% ate fish and shellfish caught in local polluted waters. Statistically significant factors associated with eating local, noncommercial fish included male gender and knowledge of the health advisory. Locally caught fish and crabs are consumed; thus, in utero and childhood exposure to these neurotoxins occurs. Interventions to promote safer choices of fish are needed.*

KEYWORDS *Contaminants, Dioxin, Health advisory, Neurotoxins, Noncommercial, Polychlorinated biphenyls.*

INTRODUCTION

The federal government sets standards for permissible levels of contaminants in commercially sold food, including fish. For fish caught and consumed from noncommercial sources, the New York State Department of Health (DOH) publishes annual health advisories when sport fish have contaminant levels greater than the federal standards. In New York State, the Department of Environmental Conservation (DEC) monitors contaminant levels in fish.[1]

The DOH health advisories are not intended to discourage fish consumption, but rather to minimize exposure to contaminants and health risks that are associated with exposure to contaminants. Fish has nutritional properties that make it an ideal protein source when prepared properly. Fish may acquire contaminants from the water in which they live and the food they eat. Some contaminants build up over time in fish and in people who consume fish.[1]

Long-lasting contaminants, such as polychlorinated biphenyls (PCBs), 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane (DDT), and cadmium, remain in the body. It may take months or years of eating contaminated fish to accumulate a body burden of health concern. A specific advisory for infants, children younger than 15 years of age, and women of childbearing age is to eat no fish from the bodies of water listed in the advisory. Mothers who eat contaminated fish before becoming pregnant may have children with developmental and learning problems, birth de-

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fects, or cancer.[1,3–11] These contaminants are known to be excreted in mother's milk and may have an adverse effect on developing organs of a young child as well.[1]

The contaminants in sport fish include PCBs, a family of man-made chemicals used in many commercial and electrical products. In the United States, most PCBs were sold as mixtures called aroclors. PCBs are stored in the fatty tissues of fish, birds, and mammals. Some studies of pregnant women suggest a link between increased exposure to PCBs and slight effects on their child's birth weight, short-term memory, and learning.[3–11] Laboratory animals had reduction of birth weight and changes in the behavior of the offspring of animals exposed before, during, and after pregnancy. Some types of PCBs cause cancer in laboratory animals. Whether PCBs cause cancer in humans is unknown.[1]

Prior to the mid-1970s, when PCB manufacturing was banned in New York, General Electric manufactured components using PCBs at its factories north of Albany. The decades of leaks, spills, and permitted drainage of chemicals made the Hudson River one of the nation's most PCB-contaminated rivers. In 1984, a 200-mile stretch of the river from Hudson Falls to the Battery in New York City was added to the government's Superfund priority cleanup list.

The objective of our project was to determine if WIC (Special Supplemental Nutrition Program for Women, Infants, and Children) participants were eating local, noncommercial fish and crabs from waters that are contaminated with chemicals that may be harmful to their health.

METHODS

Institutional review board approval was obtained with exemption of written consent prior to beginning the project. Face-to-face interviews were conducted during 12 days between July 22 and August 11, 1999. The interviews were conducted at sites administering WIC while the participants waited to see a nutritionist. Three WIC centers in East Harlem were the sites for the interviews: a building at 96th Street and Lexington Avenue next to the subway station, another affiliated with a community health center located at 104th Street and 2nd Avenue, and a hospital-based center at North General Hospital. Interviews were conducted in English and Spanish by one of six people trained to conduct the interview. The interviews took less than 5 minutes, and the interviewer filled out a survey with the responses given and gave the participant a fact sheet.

A fact sheet, "A Mother's Guide to Eating Fish in New York City," was prepared in English and Spanish to give to participants at the time of the interview. The fact sheets and survey instrument were developed in consultation with WIC directors and nutritionists, New York State DOH educators working on fish advisory outreach programs, and a community organization in West Harlem.

Of the WIC recipients, 95% agreed to participate. Primary reasons for nonparticipation included time constraints and language barriers.

Chi-square, *t* test, and binary logistic regression analyses were used to determine factors associated with eating local, noncommercial fish. Data were analyzed with SPSS (Version 10) statistical software.[2]

RESULTS

Characteristics of the study participants are presented in Table 1. Women comprised 98% of the respondents; however, in one case a couple presented together,

TABLE 1. Characteristics of participants at WIC centers in East Harlem

Characteristic	All participants, N = 220	Site 3, N = 16	Site 2, N = 111	Site 1, N = 93
Gender (female : male)	98% : 2%	100% : 0	97% : 3%	99% : 1%
Age, mean (years)	27.8 (16–67)	27.4 (18–52)	27.3 (16–54)	28.5 (16–67)
Community (by ZIP code), %				
East Harlem	71	75	66	75
Bronx	22	19	26	18
Queens	7	6	8	7
Race, %				
Hispanic	57	25	48	74
Black	39	69	45	26
White	2	0	4	0
Other	2	6	3	0

and the female was interviewed. Four men came with their children and were the source of information during the interview. The mean age of the participants was 27.8 years, and most were Hispanic (57%) or black (39%). Of the participants, 19% were pregnant, 5% were postpartum and breast-feeding, 13% were postpartum but not breast-feeding, 22% were receiving services primarily for a child younger than 1 year of age, and 41% were receiving services primarily for a child 1 to 5 years of age.

Of those interviewed, 200 (91%) reported that they ate fish or shellfish (hereafter combined and referred to as fish for simplicity). Among those eating fish, the frequency was assessed for overall fish consumption (commercial plus noncommercial fish, all species combined). Results are reported as the number of fish meals eaten per month over the past few months (Table 1): 51 responders (26%) ate fish once a month or less; 66 (33%) ate fish two to three times per month; 43 (22%) ate fish four to seven times per month; and 38 (19%) ate fish eight or more times per month. Two reported not knowing the number of fish meals eaten per month.

Many types of fish were consumed. Table 2 lists the variety of fish the participants reported eating in the past few months. Often, if the parent ate fish, the children also ate fish, which applied to 131 of 199 (66%) participants with children. Of the respondents, 72% reported getting their fish from local markets. With regard to method of preparing fish, 55% reported eating the fish with the skin on, and 77% fried the fish. Of respondents, 5% reported frying crabs, and 9% ate the internal organs of crabs.

Notably, among the 200 respondents who ate fish, 22 (11%) reported eating noncommercial fish caught in local waters. Four participants were included in the 22 even though they were uncertain about where the fish was caught, but knew that it was from a family member or friend who fished in local waters.

Participants reporting that they ate local, noncommercial fish included 1 woman who was pregnant, 4 women who were postpartum and not breast-feeding, and 1 woman who was postpartum and breast-feeding. The remaining 16 were mothers or fathers with children.

Statistical analyses were performed only among WIC participants who reported that they ate fish, comparing participants who ate local, noncommercial fish to

TABLE 2. Fish and shellfish eaten by WIC participants

	No.	%*
Whiting	90	(45)
Tuna (fresh and canned)	76	(38)
Salmon (fresh and canned)	62	(31)
Flounder	58	(29)
Porgy	39	(19)
Bluefish	37	(18)
Codfish	32	(16)
Catfish	23	(11)
Red snapper	19	(9)
Perch	13	(6)
Mackerel and sardine	12	(6)
Redfish	11	(5)
Bass	8	(4)
Shark, swordfish, and mahimahi	3	(1)
Shrimp	151	(75)
Crab	65	(32)
Clam	50	(25)
Octopus and squid	9	(4)
Albacore, oyster, and conch	3	(1)

*Denominator is participant eating fish or shellfish (N = 201).

those who ate only commercial fish. Table 3 shows that the WIC participants who ate local, noncommercial fish were about 3 years older than those who ate only commercial fish. This age difference was not statistically significant. Participants in both groups had, on average, 2 children. A positive association was found between frequency of eating fish per month and local, noncommercial fish consumption, but this trend was not statistically significant, $P > 0.05$.

Chi-square analysis (Table 4) was performed for each fish consumption characteristic asked on the questionnaire. The statistically significant factors associated with eating local, noncommercial fish on chi-square analysis include male gender, knowledge of the health advisory, broiling fish, cooking crabs whole, and eating the internal organs of crabs. Of the 22 participants eating local, noncommercially caught fish, 12 (55%) were aware that there are health advisories about eating fish caught in local waters, while fewer (29%) of the other participants, who only ate commercial fish, had knowledge of the advisories. Of the 4 male participants, 2 ate local, noncommercial fish.

The significant factors from Table 4 were analyzed in a multivariate logistic regression model with the outcome variable being local, noncommercial fish eaters

TABLE 3. Results of *t* test analysis

	Mean difference	95% Confidence interval		Significance ($P \leq .05$)
Fish eating, times per month of	–1.7	–3.5	0.1	.21
Age, years	–3.1	–8.4	2.3	.24

TABLE 4. Results of chi-square analysis

	Odds ratio	95% Confidence interval		Significance ($P \leq 0.05$)
Pregnant?	0.4	0.1	1.7	.2
Fish cooked with skin on	0.9	0.4	2.3	.9
Fish cooked whole	1.3	0.5	3.3	.6
Fish cooked as steaks	1.4	0.5	3.9	.5
Fish cooked as fillets	0.6	0.3	1.5	.3
Fish cooked by frying	0.9	0.3	2.6	
Fish cooked by baking	1.2	0.5	3.0	.6
Fish cooked by grilling or barbecueing	1.4	0.3	6.7	.7
Fish cooked by broiling	4.5	1.7	12.2	.001
Fish cooked by poaching	0.8	0.2	2.7	.7
Fish cooked by smoking	4.2	0.4	48.5	.2
Crabs cooked whole	2.8	1.1	6.9	.02
Crabs cooked in pieces	1.7	0.5	5.4	.4
Crabs cooked by frying	1.4	0.2	12.0	.8
Crabs cooked by baking	4.4	0.8	25.4	.08
Crabs cooked by grilling	8.5	0.5	140.6	.08
Crabs cooked by broiling	3.0	0.7	12.0	.1
Crabs cooked by steaming	1.8	0.7	4.3	.2
Do you eat the green "mustard" of crabs?	5.9	0.9	37.2	.04
Are you aware of the health advisory?	2.6	1.1	6.5	.03
Male gender	8.9	1.2	66.3	.01

or not. Table 5 shows the factors that were strongly associated with eating local, noncommercial fish. Two associations were statistically significant, male gender ($P = .04$) and broiling fish ($P = .002$). Several other factors that were significant on chi-square analysis no longer remained significant in the multivariate logistic regression model. When these factors were evaluated one at a time in the model with the three factors in Table 5 to see if they would change the model or the odds ratios for these factors, none achieved statistical significance.

DISCUSSION

This cross-sectional survey identified an at-risk population: low-income women of childbearing age and children younger than 15 years of age at WIC centers that are eating noncommercial fish. WIC is a federally funded program provided by the US

TABLE 5. Results of multivariate logistic regression analysis

Factor	Odds ratio	95% Confidence interval		Significance ($P \leq 0.05$)
Broiling fish	4.9	1.8	13.4	.002
Grilling or barbecueing crabs	13.3	0.8	225.7	.07
Gender of participant	9.2	1.1	77.0	.04

Department of Agriculture (USDA) and administered by state agencies. The mission of WIC is, by providing nutritious foods to supplement diets, information on healthy eating, and referrals to health care, to safeguard the health of low-income women, infants, and children who are at nutritional risk. Requirements for participation include women who are pregnant, postpartum, and breast-feeding, as well as infants to 12 months and children up to 5 years of age. Additional requirements include residing in New York State (legal immigration status not required), family income below 185% of the federal poverty income guidelines, and a documented medical or nutritional risk, such as anemia or history of pregnancy complications. Nationally, over 7 million participants are served, and in New York, over 460,000 participants are served monthly.[13]

Our survey estimates the total number of commercial and noncommercial fish and crab meals per month by WIC participants; separate fish meals for any particular type of fish is not available. This estimate is from the participant's memory and is subject to recall or reporting bias. There are many reasons that these participants may be eating fish caught from local waters by family or friends. In this poor urban population, subsistence eating may be a major reason for eating noncommercial fish. This information was not available from our survey. However, on analysis of number of children per family, the mean number of children per family did not change between those eating noncommercial fish and the entire population surveyed. On asking about purchasing fish from local markets, participants reported that these markets have the freshest fish.

In the absence of measurement of chemical contaminants by the participants, the amount of exposure is uncertain. Levels of PCBs, mercury, and other contaminants of concern are probably relatively low as was reported by many of the studies of humans (discussed below). PCBs were the focus of our survey since some behaviors, such as method of fish preparation, can influence the contaminant exposure. Behavior modification may be the emphasis of future projects if this survey finds any at-risk behaviors. Unfortunately, similar interventions are not helpful in reducing exposure to mercury. Mercury is present in the fish on the advisories at a level similar to any other fish from commercial sources. Our educational sheet that was provided to the participants and WIC staff did refer to contaminants in fish, including PCBs.

The developing unborn child is very vulnerable to these chemicals, and several studies have shown neurobehavioral and developmental cognitive deficits associated with in utero exposure.[3–5,7–10,14,15] A cohort of 212 children in Michigan included 167 children who were delivered to mothers who ate Lake Michigan fish. Postnatal breast-feeding of these children was not associated with poorer performance on any of the tests.[15] A similar association with reduced IQ scores was found in Taiwanese children whose mothers had ingested rice oil contaminated with PCBs and furans.[3] In most of the testing, the exposed children had lower scores on developmental testing and more behavior disorders.[4] In a cohort of 395 Dutch children, background PCB and dioxin exposure resulted in poorer cognitive functioning in children 42 months of age. No associations between lactation and exposure to PCBs or dioxins or current PCB body burden and cognitive abilities were found.[5]

The Oswego Newborn and Infant Development Project is a prospective longitudinal study to examine the behavioral effects in newborns, infants, and children of prenatal and postnatal exposure to persistent organic pollutants. Maternal consumption of Lake Ontario sport fish, which is contaminated with a wide range of persistent toxic chemicals, including PCBs, is of special concern. The survey of 279

pregnant women in the Oswego, New York, area found that maternal consumption of Great Lakes fish increases the risk of prenatal exposure to the most heavily chlorinated PCBS. Only the most heavily chlorinated PCBs, which are more persistent, correlated with neurobehavioral changes in newborns of women who consumed Lake Ontario fish. There is evidence from this study that consumption of contaminated Great Lakes fish causes measurable decrements in early neonatal behavioral functions, including an increase in abnormal reflexes and startles, tremors, and other changes in autonomic functioning and poorer habituation (response decrement) to repeated auditory, tactile, and visual stimulation.[7] Testing at 6 months and 12 months showed a dose-dependent relationship between umbilical cord blood PCB levels and poorer performance at both ages.[8]

With all these studies, the observed relationship between exposure and outcome may be due to a third unmeasured influence. However, reproduction of similar results in different circumstances by different studies adds strength to the findings. All the studies find a greater vulnerability of the unborn child to transplacental exposure to PCBs, even though a greater concentration of PCBs is transferred postnatally via breast milk.[9]

Although a few points reduction in IQ score, for example, in the group of children whose mothers ate Lake Michigan fish, seems small, this reduction represents an average among the group. The analysis by Jacobson using the McCarthy Memory Scale scores shows that there was a marked range of differences in performance by children in the highly exposed group. These data indicate that prenatal exposure to PCBs significantly increases the likelihood that a child will be unable to perform well in school. As with other chemicals, there may be marked individual differences in vulnerability when the effects of an exposure are examined on a case-by-case basis.[9]

In another cohort in North Carolina, 859 newborns were enrolled and evaluated for the effects of background perinatal exposure to PCBs and dichlordiphenyldichloroethene (DDE). At 18 months and 24 months, the children were tested. The scores were 4 to 9 points lower among children in the top fifth percentile of transplacental PCB exposure. Later testing, at 3, 4, and 5 years, found no association between exposure to PCBS and reduced scores on cognitive testing. There were not any consistent effects from exposure to PCBs through breast milk or from dichlordiphenyldichloroethene exposure.[10,11]

Prenatal exposure to PCBs is associated with neurodevelopmental deficits, although the exact mechanism is not understood. Research using the Dutch cohort looked at thyroid hormone status as it relates to exposure to PCBs and dioxins. Thyroid hormones are essential for normal behavioral, intellectual, and neurological development. Higher levels of PCBs, dioxins, and furans in human milk correlated significantly with lower maternal plasma levels of total triiodothyronine and total thyroxine and higher infant plasma levels of thyroid-stimulating hormone during the second week and third month after birth. Infants exposed to higher levels of PCBs and dioxins also had lower plasma, free thyroxine, and total thyroxine levels in the second week after birth.[12] A review by Hauser[16] examined the relationship between thyroid hormone function and PCB exposure. There seems to be increasing evidence from animal and human research that low-level exposure to PCBs and dioxins during the perinatal period can impair learning, memory, and attention processes of offspring.[12,16]

In our survey, approximately 10% of those surveyed reported eating local, noncommercially caught fish. This is similar to the result of a study by Tilden et al.,[16]

which used a random-digit-dialed telephone survey of 8,306 adults in Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin; it found that about 8% ate Great Lake sport fish during the preceding year. As in our results, men reported eating sport fish more frequently than women. About 50% of those eating sport fish knew of the health advisories. Unlike our sample, this telephone survey had only 7% minority representation.

A survey of New York anglers in the Buffalo area found that the use of cleaning and cooking methods was significantly higher among persons aware of the health advisories.[18] In our survey, eating local, noncommercial fish was significantly associated with knowledge of the health advisories and with some safer cooking methods, such as broiling fish. However, when both factors were included in a multivariate logistic regression model, only broiling fish remained statistically significant. Although they still choose to eat local, noncommercial fish, those who were aware of the health advisory's contents used safer methods of preparation, such as broiling their fish.

The PCBs deposited in the sediment of rivers and lakes are disturbed by dredging, shipping, and storms. This environmental change reintroduces PCBs into water and promotes the persistence of PCB residues in fish and other aquatic organisms. The method of cooking has been shown in a number of studies to reduce the level of PCB residues in fish. Broiling lake trout reduced PCBs by 53%, while roasting or cooking in the microwave resulted in slightly lower losses, ranging from 26% to 34%. Trimming the fat and removing the skin is important to reduce the level of PCB exposure during consumption of sport fish. Irradiation of raw fish did not affect the level of PCBs. Removing the hepatopancreas from blue crabs prior to cooking also resulted in a reduction of PCBs.[19,20]

It is not known why there was more consumption of crabs with the hepatopancreas among those eating local, noncommercial fish and crabs. It may be due to the fact that the crabs are being cooked whole, and thus the hepatopancreas is not being removed.

CONCLUSION

Women of childbearing age and children are eating local, noncommercial fish from bodies of water listed in the health advisories. The WIC centers are a good place to identify and provide further information to parents about the subtle long-term effects to children exposed in utero. These children are at a greater risk for problems with learning and behavior.

It is unclear whether local, noncommercial fish is being eaten due to its affordability and efforts to feed urban families on fixed incomes. This needs further study. Further education may help inform these men and women of the long-term effect of eating local, noncommercial fish on their child's development. Knowledge of the health advisories may help these WIC participants understand the effect of exposure to contaminants on long-term learning in their children.

If this local, noncommercial fish is a necessary nutritional source, then further education to remove contaminants by certain food preparation methods must be emphasized. Removing the hepatopancreas from crabs prior to cooking, trimming fat, and cooking fish with the skin off can certainly reduce exposure to some contaminants, such as PCBs and dioxins. However, methylmercury exposure cannot be reduced by the same strategy.

The nutritionists and staff at the WIC centers are very interested in any ways

they can assist their enrollees. Care must be taken not to discourage eating commercial fish that does not contain contaminants. Furthermore, there is currently no need to discourage breastfeeding, even if exposure to PCBs or dioxins or other contaminants has occurred.

Health care professionals rarely assess exposure to PCBs or dioxins via measurement of maternal serum, breast milk, or infant cord serum. These analyses are expensive, and there are no established threshold values.[21] Education of health care professionals is necessary to instruct women of childbearing age. Other important groups to educate are community leaders, such as clergy and political figures.

There is no way to remove PCBs from the body once ingested, and their half-life may be longer than 6 years according to findings from the study of the exposed women in Taiwan. Therefore, prevention of exposure is the best recommendation. The participants in WIC were receptive to learning about reduction of exposure from contaminants such as PCBs. Further education would be beneficial for this population.

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REFERENCES

1. New York State Department of Health 2002–2003 Advisories. *Chemicals in Sportfish and Game*. Available at: www.health.state.ny.us/nysdoh/environ/fish.htm. Accessed March 21, 2003.
2. SPSS, Inc. *SPSS*. Version 10. Chicago, IL: SPSS, Inc. Available at: www.spss.com. Accessed January 29, 2003.
3. Chen Y-CJ, Guo Y-L, Hsu C-C, Rogan WJ. Cognitive-development of Yu-Cheng ("oil disease") children prenatally exposed to heat-degraded PCBs. *JAMA*. 1992;268:3213–3218.
4. Rogan WJ, Gladen BC, Hung K-L, et al. Congenital poisoning by polychlorinated biphenyls and their contaminants in Taiwan. *Science*. 1988;241:334–336.
5. Patandin S, Lanting CI, Mulder PGH, Boersma ER, Sauer PJJ, Weisglas-Kuperus N. Effects of environmental exposure to polychlorinated biphenyls and dioxins on cognitive abilities in Dutch children at 42 months of age. *J Pediatr*. 1999;134:33–41.
6. Stewart P, Darvill T, Lonky E, Reihman J, Pagano J, Bush B. Assessment of prenatal exposure to PCBs from maternal consumption of Great Lakes fish: an analysis of PCB pattern and concentration. *Environ Res*. 1999;80:S87–S96.
7. Stewart P, Reihman J, Lonky E, Darvill T, Pagano J. Prenatal PCB exposure and neonatal behavioral assessment scale (NBAS) performance. *Neurotoxicol Teratol*. 2000;22:21–29.
8. Darvill T, Lonky E, Reihman J, Stewart P, Pagano J. Prenatal exposure to PCBs and infant performance on the Fagan test of infant intelligence. *Neurotoxicology*. 2000;21:1029–1038.
9. Jacobson JL, Jacobson SW. Evidence for PCBs as neurodevelopmental toxicants in humans. *Neurotoxicology*. 1997;18:415–424.
10. Rogan WJ, Gladen BC. PCBs, DDE, and child development at 18 and 24 months. *Ann Epidemiol*. 1991;1:407–413.

11. Gladen BC, Rogan WJ. Effects of perinatal polychlorinated biphenyls and dichlorodiphenyl dichloroethene on later development. *J Pediatr*. 1991;119:58–63.
12. Koopman-Esseboom C, Morse DC, Weisglas-Kuperus N, et al. Effects of dioxins and polychlorinated biphenyls on thyroid hormone status of pregnant women and their infants. *Pediatr Res*. 1994;36:468–473.
13. Personal communication with Fabio Coazia, August 2001. Available at: www.fns.usda.gov/wic/. Accessed January 29, 2003.
14. Johnson BL, Hicks HE, Cibulas W, et al. Public health implications of exposure to polychlorinated biphenyls (PCBs). Agency for Toxic Substances and Disease Registry (ATSDR), pp. 1–36. Available at: www.atsdr.cdc.gov/DT/pcb007.html. Accessed January 29, 2003.
15. Jacobson JL, Jacobson SW. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. *N Engl J Med*. 1996;335:783–789.
16. Hauser P. Resistance to thyroid hormone: implications for neurodevelopmental research. *Toxicol Ind Health*. 1998;14:85–101.
17. Tilden J, Hanrahan LP, Anderson H, et al. Health advisories for consumers of Great Lakes sport fish: is the message being received? *Environ Health Perspect*. 1997;105:1360–1365.
18. Connelly NA, Knuth BA, Vena JE. *New York State Angler Cohort Study: Health Advisory Knowledge and Related Attitudes and Behavior, With a Focus on Lake Ontario*. Ithaca, NY: Dept of Natural Resources, Cornell University; 1993. Human Dimensions Research Unit Series 93-9.
19. Zabik ME, Hoojjat P, Weaver CM. Polychlorinated biphenyls, dieldrin and DDT in lake trout cooked by broiling, roasting or microwave. *Bull Environ Contam Toxicol*. 1979;21:136–143.
20. Zabik ME, Zabik MJ. Polychlorinated biphenyls, polybrominated biphenyls, and dioxin reduction during processing/cooking food. In: Jackson LS, Knize MG, Morgan JN, eds. *Impact of Processing on Food Safety*. New York, NY: Kluwer Academic/Plenum Publishers; 1999:213–231.
21. Korrick SA, Altshul L. High breast milk levels of polychlorinated biphenyls (PCBs) among four women living adjacent to a PCB-contaminated waste site. *Environ Health Perspect*. 1998;106:513–518.